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A Detail Investigation on Structural and Optical Properties of ZnO: Sn Prepared by Co-Precipitation Method

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Abstract

ZnO: Sn nanopowders were synthesized by co-precipitation method using Zinc acetate dihydrate and Tin chloride as a precursors. Co-precipitate of ZnO: Sn nanopowders with pure Zinc and different volume fraction of Tin chloride (0.250, 0.050, 0.1 M) and were obtained by calcination process at 500 ^{o}C. From the XRD studies revealed that the grain size gradually decrease during increase content of the Sn. The transformation of structural properties of the Sn dopant were confirmed by FESEM. From the EDAX result confirm the presence of ZnO and Sn in the powder.From the FT-IR spectra the chemical bonding and the presence of particles of Sn were confirmed. From the UV-Vis spectra the doped Sn increase band gap than pure Zinc were confirm. From the PL studies blue region of the ZnO: Sn nanopowders were confirm. These results indicate that the crystallinity and structural of ZnO nanopowders are significantly affected by Sn dopant.

Keywords : *ZnO, Tin, ZnO: Sn nanopowders, Co-precipitation method.*

1. INTRODUCTION

Zinc oxide is a wide range band gap (3.37 eV) semiconducting material which has been widely used in transparent conducting films, gas sensor, surface acoustic wave device and photo catalyst and optoelectronic devices. Unique properties such as low resistivity, non-toxic, highly transparent in visible range and high trapping characteristics of ZnO-based materials have been extensively investigated. Recently, many researchers have reported that various morphologies and structures of ZnO can be synthesized by specific synthesis methods. In typical, the functional properties of ZnO nanomaterial can be tailored using physical and chemical methods. Moreover, the enhancement of ZnO properties could be further obtained by controlling its structure to be in low dimensional features such as nanowire and nanorod. Metal doped ZnO nanostructures have been of great interest for improving ZnO properties such as electrical, optical and magnetic to meet the requirement of potential applications. Based on previous works, it had been reported that ZnO was effectively doped with Al, Ga, In, Sn and S. Amount of the dopants could have great influence on the structure and surface morphology of ZnO. Along with other research works, the physical and chemical properties of ZnO were successfully synthesized by the incorporation with Sn. Several techniques such as sol-gel, solid state reaction, hydrothermal and co-precipitation process have been successfully employed to synthesize ZnO-based nanopowders. Among them, coprecipitation method is one of effective technique for synthesizing various kinds of metal oxide materials due to simply, low cost and large capability to produce particles of single and multicomponent metal oxide. In this present work, ZnO:Sn nanopowders were synthesized by coprecipitation process.

2. EXPERIMENT

2.1 Synthesis

The synthesis of Zno:Snnanopowders prepared by co-precipitation method. First take the precursor of Zinc acetate dehydrate constant at 0.1 M was dissolved in 100 ml deionized water. Then the variation of mole concentrations (0.025, 0.050, and 0.1) tin dichloride were added in dissolved Zinc acetate dehydrate. The added solution was homogeneously stirred for one hour,

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after one hour of stirring the ammonia solution was added for increasing for pH level 14. Finally the chemical co-precipitation was achieved, and the precipitation samples were washing with deionized water until pH became neutral (pH7) Prepared coprecipitation were dried at 80^{o}C for 24 hours in an oven. Finally synthesized ZnO:Sn nanopowders were calcined at 500^{o}C for 4 hours.

2.2 Characterization

ZnO:Sn nanoparticles were characterized on structural analyses by using X-Ray Diffraction. The Fourier Transform Infrared Spectroscopy was used to study the wavelength of a materials. Surface analysis of a materials are taken by Scanning Electron Microscopy and also optical behaviour analaysised by using UV-Visible spectroscopy. And also excitation of photon levels determined by photoluminescence were carried out.

3. RESULT & DISSCUSION

The structural properties of synthesised nanopowders were detected by using particles X-ray method. The obtained X-ray diffractogram of ZnO and ZnO:Sn nanopowders were shown (Fig.1). The obtained Peaks of nanopowders confirms the presence of sharp and high intensity peaks, with high crystalline nature. This peaks are compared with JCPDS card no (36-1451) and found to be proximity with earlier literatures. Diffraction peaks at 31.96, 34.60, 47.73, 56.78, 63.20, and 68.12, are corresponding to the indices planes of (100), (002), (200), (102), (110), (103) and (112). The structure of the prepared zinc oxide sample is confirmed as hexagonal wurtizite. The obtained grain sizes of the samples are found to be as 20.26 nm, 19.8nm, 17.8nm, 11.44nm. Which is gradually decreased with respect to the Sn Concentration.From this it is observed that, the planes in the pattern were slightly shift with respect to the Sn doping concentration during arbitrary orientation of the crystal. This plane shift with decreased crystallite size during Sn doping formed due to the variation of nucleation centre densities [11]. This also results in the formation smaller crystallites.

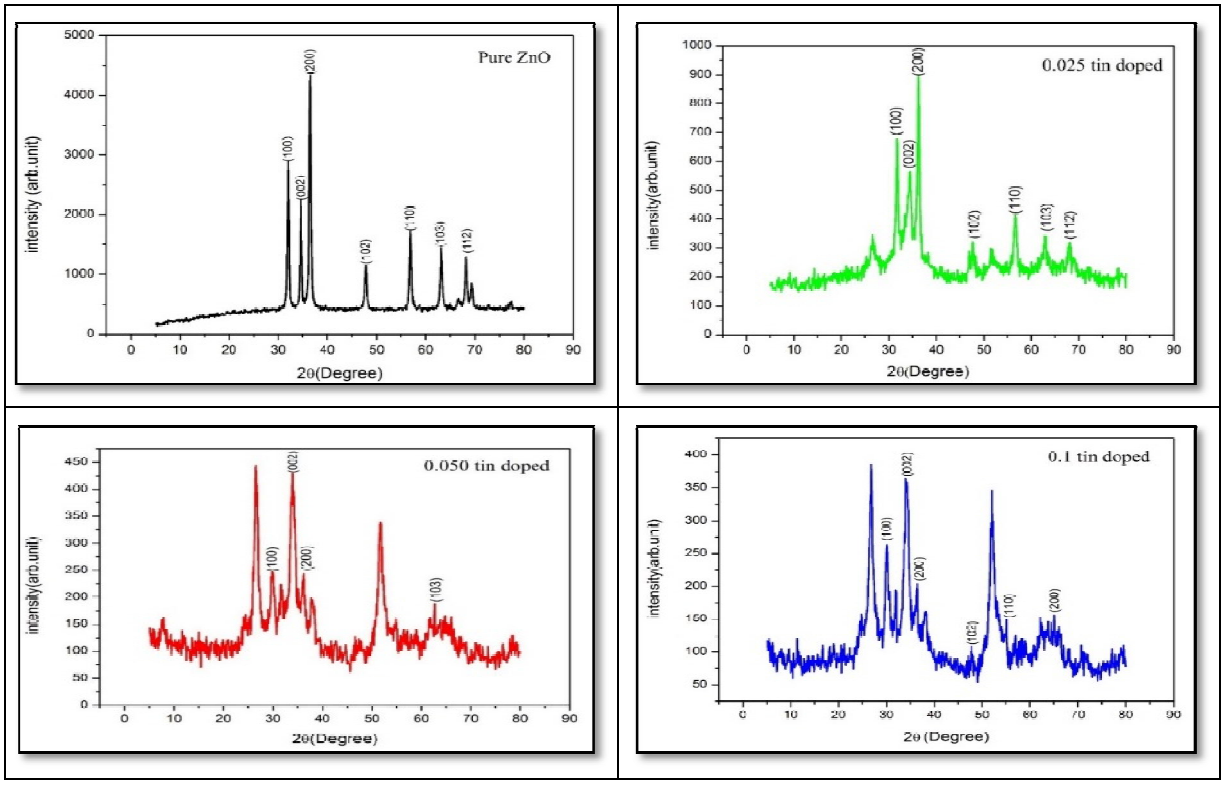

Fig. 1: XRD images of pure zinc and different variation of mole concentrations (0.025, 0.050, and 0.1) doped tin dichloride

The SEM image (Fig. 2) confirms the formation of ZnO:Sn nanoparticles. It was noted that the Sn particles were evenly agglomerated with ZnO particles. When doping concentration of Sn is increased, the grain size agglomeration in nanoparticle also increases and results in the formation of tiny crystal particles. From

this, it is confirmed that the morphological properties of nanoparticles are in good agreement with the structural properties.

Functional groups of all nanoparticles were analysed by using FTIR spectra in the range of 400 cm^{-1} to 4000 cm^{-1}. The FTIR spectra of the pure ZnO and Sn doped ZnO with the various concentration of 0.025, 0.050 and 0.1 are shown (Fig. 3). The obtained spectra confirms the presence of relevant functional groups in the prepared particles. The pure ZnO peak were observed in the 565cm^{-1} region and O-H vibrational bending and vibration stretch peaks are observed in the (1559,3503) cm^{-1} region. At 0.250 concentration ZnO and Sn peaks were observed in 561cm^{-1}, and 1130cm^{-1} region, O-H vibrational bending and vibration stretch were assigned at (1523,3617)cm^{-1} region. At 0.050 concentration ZnO and Sn peaks were observed in 566cm^{-1} and 1069cm^{-1} region, O-H vibrational bending and vibration stretch were assigned at (1546, 3690)cm^{-1} region. This peaks were observed at 560cm^{-1}, 1071 cm^{-1} 1546 cm^{-1}, 3655cm^{-1} region for the 0.1 M concentration .The hydroxyl O-H groups are water adsorbed in the all samples.

The UV-Vis spectra of pure Zinc and Sn doped ZnO nano powder prepared with the various Sn doping concentrations (0.025, 0.050 and 0.1) are shown (Fig 4.). The absorption peaks are observed at 334, 331, 340 and 340 nm respectively. The doping of tin with Zinc oxide were confirmed by the small shift in absorption region The band gap of pure and Sn doped ZnO nanoparticles at different concentration was found to be in the range of 3.7 to 3.6 eV. With increase in Sn concentration, band gap value of the sample are decreased and found to be better than pure Zinc oxide. When the Sn concentration is increased, the blue shift were observed in the excitation absorption band.

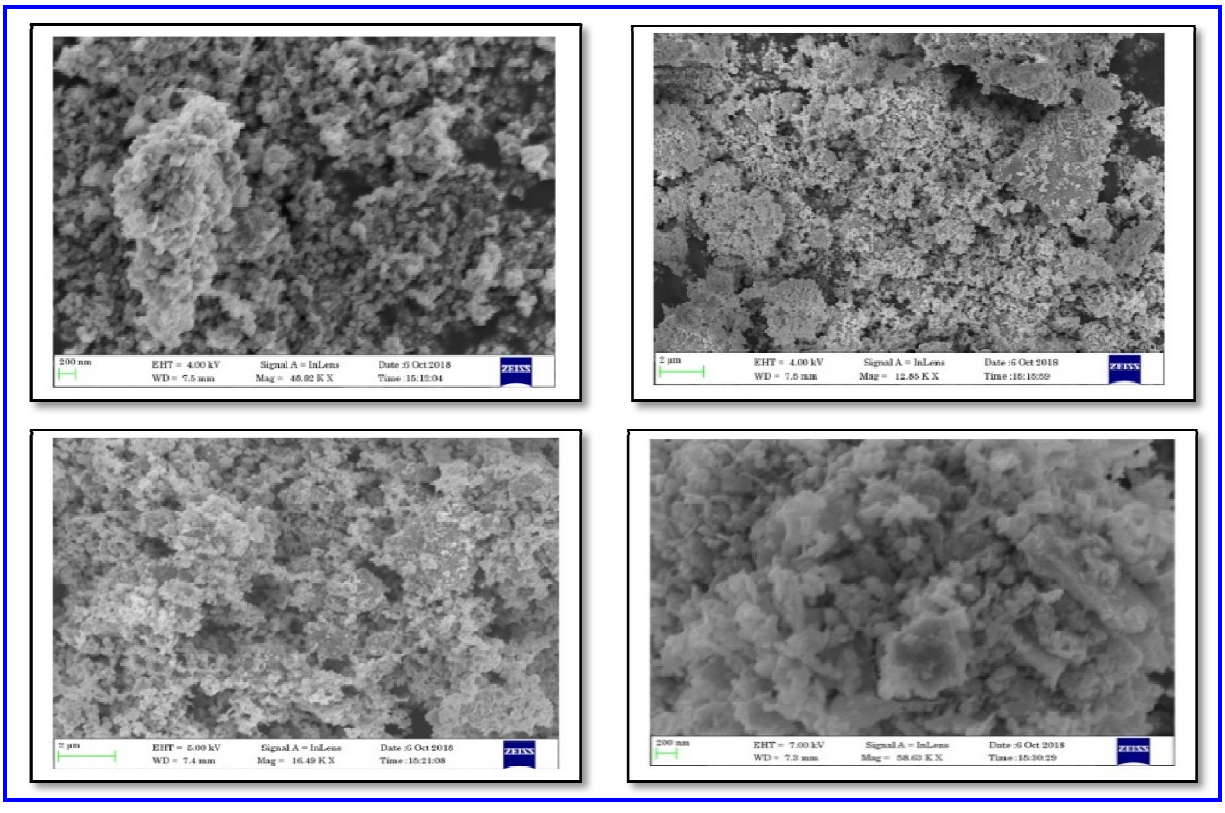

Fig. 2: SEM images of pure zinc and different variation of mole concentrations (0.025, 0.050, and 0.1) doped tin dichloride

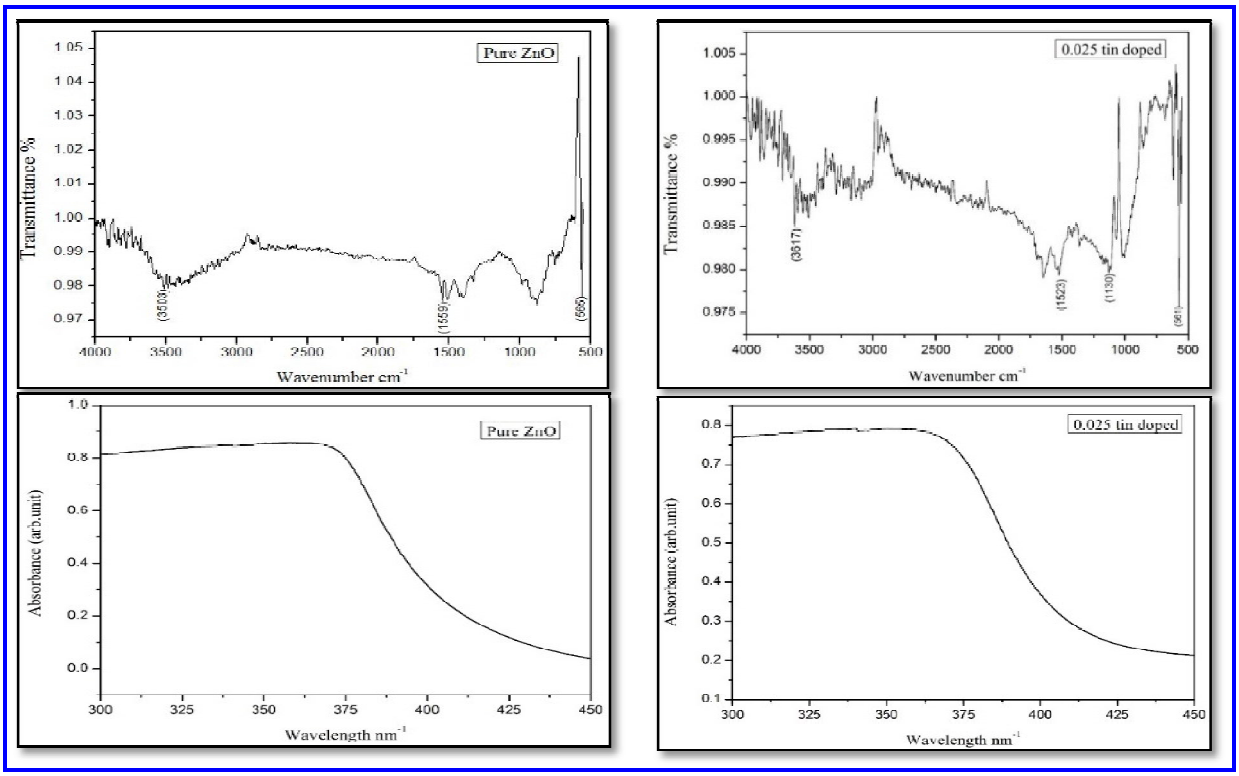

Fig. 3: FTIR images of pure zinc and different variation of mole concentrations (0.025, 0.050, and 0.1) doped tin dichloride

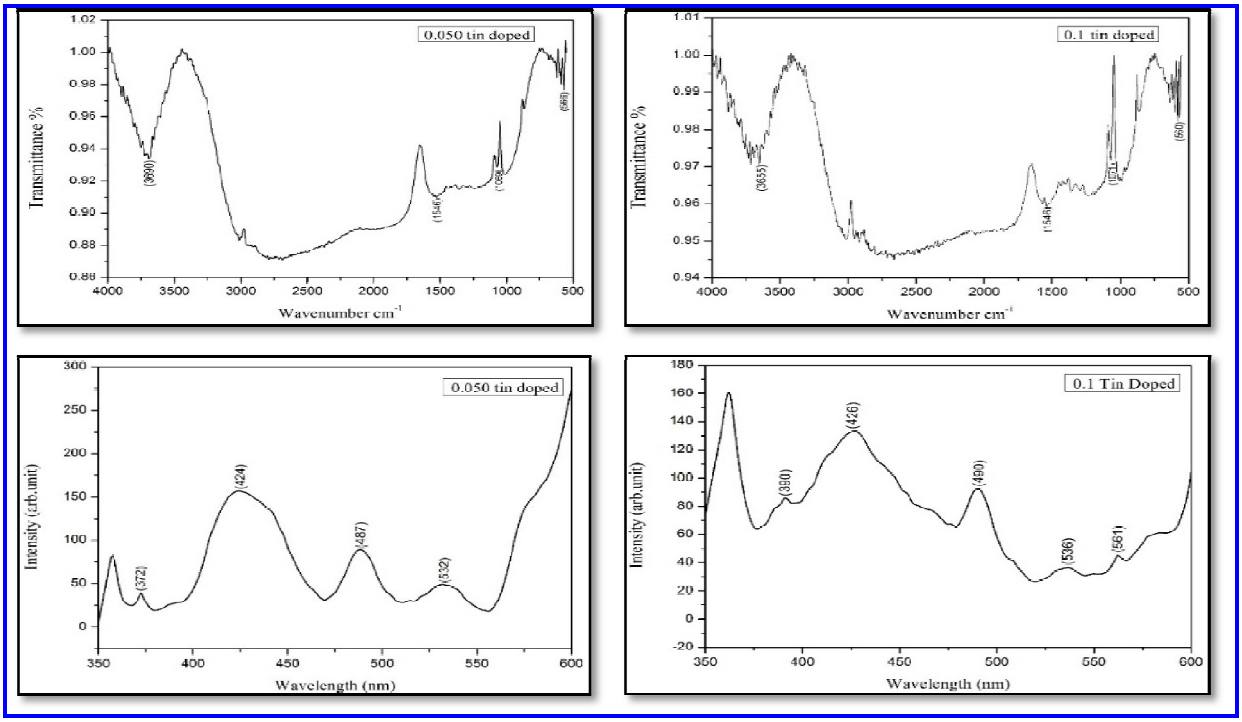

Fig. 4: UV images of pure zinc and different variation of mole concentrations (0.025, 0.050, and 0.1) doped tin dichloride

The Photoluminescence patterns of the ZnO and Sn doped Zn was recorded at room temperature. The emission and excitation peaks are observed by the luminescent emission peaks. And it is observed in the range of 390 nm, 366 nm, 372 nm and 390 nm, those are present in violet region and it related to Near Band Edge (NBE) emission. The peaks in the range of 425 nm, 398 nm, 424 nm and 426 nm exhibits the band excitation. It presents in the violet region. The sharp and high intensity peaks of 489 nm and 540 nm indicates the interstitials of Zinc and Oxygen ions. Another high peaks of 489 nm, 487 nm and 490 nm indicates the interstitials of ZnO and Sn ions. These are observed in blue region. The slightly increased and decreased intensity peaks are observed in the region of 450 nm, 398 nm, 424 nm and 426 nm those ranging peaks are shown the transition donor level due to conduction band to valence band. This results are in good agreement with the obtained UV-Vis Studies.

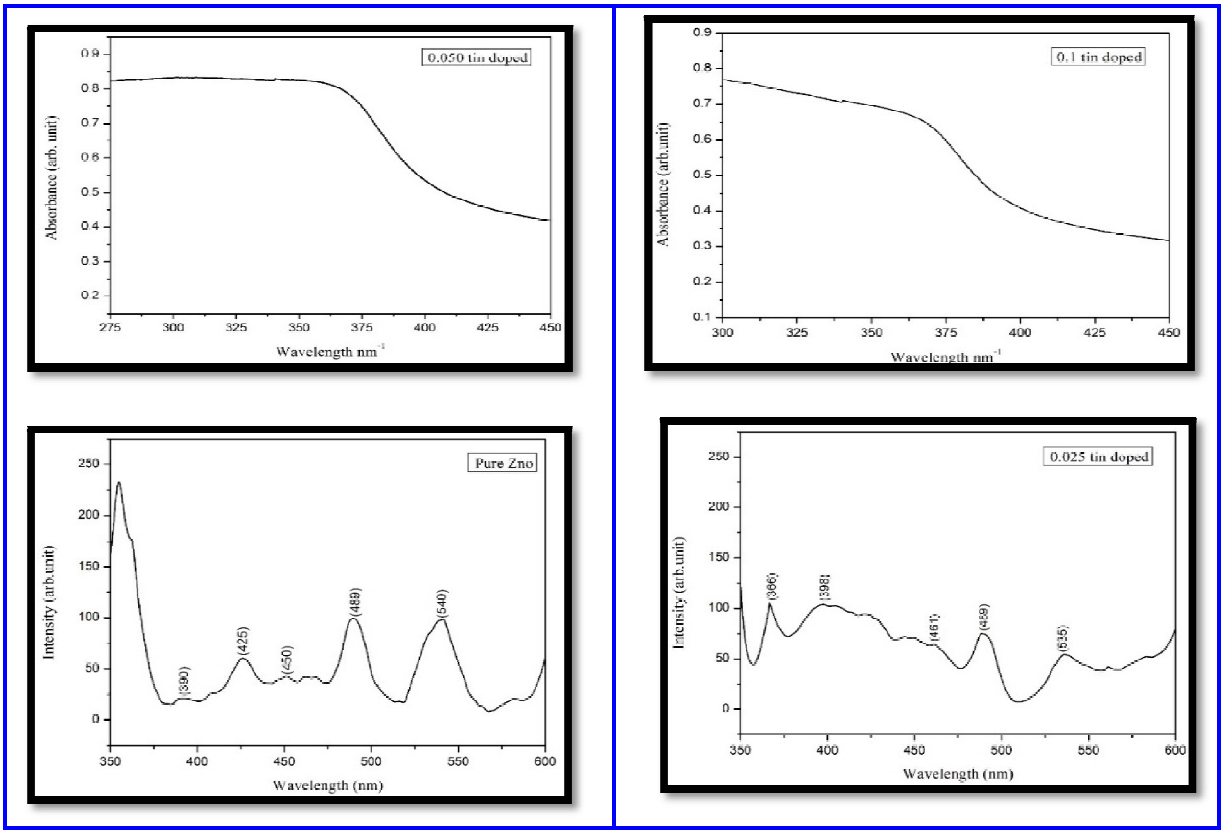

Fig. 5: PL images of pure zinc and different variation of mole concentrations (0.025, 0.050, and 0.1) doped tin dichloride

4. CONCLUSION

In this work pure ZnO and Sn doped ZnO with various concentration were synthesized by co-precipitation method. This samples were dried at 80°C for 24 hours followed by calcination at 500°C for 4 hours. The XRD patterns revealed that pure ZnO exhibited hexagonal structure, due to Sn concentration this phase were shifted into cubic structure. The grain size are decreased with respect to the concentration of Sn. The surface morphology (FE-SEM) confirms the formation of doped nanopowders with slight variation in the morphology. FTIR spectra revealed the presence of relevant function groups and chemical bonding in pure ZnO and ZnO:Sn nanoparticles. UV- Vis results shows that optical band gap values are decreased with respect to the Sn concentration. And the PL spectra shows the increasing in emission wavelength with respect to the

doping concentration. The results are in good agreement with UV-Vis energy band gap values. From this it is concluded that the optical band gap and luminescent of prepared nanopowders were highly depend on dopant (Sn) concentration.

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